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WORKSHOPS ON RESEARCH AND FUTURE ACTIVITIES NEEDS

by

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16. ABSTRACT

Presented are summaries of discussions of needs for future research and professional activities in urban stormwater quality as presented by participants in the Engineering Foundation Conference on Urban Runoff Quality held in Henniker, New Hampshire, in June 1986. The topics include pollution sources and receiving water impacts, modeling and data management, institutional issues, NPDES permits and data requirements, and control technology.

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Workshops on Research and Future Activities Needs

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Introduction

On the last night of the conference, participants met in small groups to discuss needs for future research and professional activities in urban stormwater quality. During the conference, a questionnaire listing proposed topical areas was given to participants, along with instructions to indicate their first three preferences and to propose additional discussion areas. The questionnaires were collected and participants were assigned to workgroups according to their wishes. Each workgroup met for approximately 3 hours and prepared a report that was discussed by all participants on the final day.

The topic of each workgroup is given in Table 1 and their written reports are attached. Individual workgroup reports should be read in their entirety to appreciate each group's concerns. This paper is an attempt to summarize the workgroup reports and to draw from them some common recommendations for the engineering and scientific community.

Table 1. List of Workgroup Topics

1. Pollution Sources and Receiving Water Impacts
2. Modeling and Data Management
3. Institutional Issues
4. NPDES Permits and Data Requirements
5. Control Technology (Two Groups)

Workgroup on Pollution Sources and Receiving Water Impacts

The workgroup on pollution sources and receiving water impacts identified several research needs for evaluating impacts of stormwater. One major need is development, refinement and standardization of tools and techniques to assist in identifying, evaluating and communicating impacts of stormwater. Particular needs include methods to determine when a beneficial use is impaired or threatened and to evaluate the capacity of a receiving water to assimilate stormwater

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discharges. This would include methods for evaluation of chemical and biological water quality and measures of habitat adequacy. Other research needs include disposal of residuals from stormwater pollution control facilities and impacts of control measures on groundwater.

A general need is a better understanding of causative bio-geochemical agents that impair beneficial uses. Stormwater events are episodic and shortlived and it was thought that the basic environmental sciences are lacking in understanding the impacts of these events. Specific needs include a better understanding of sediment-water interactions, a method for identifying problem-causing forms of pollutants, and techniques for identifying sublethal stress in biota.

The workgroup recommended establishment of a national clearinghouse for collection and distribution of information related to all aspects of stormwater management, ranging from Manuals of Practice to ordinances and case law related to stormwater. In this workgroup, as in several others, there was a perception that much valuable information exists at the state and local level but there is, at present, no mechanism to communicate this information.

Workgroup on Modeling and Data Management

The workgroup on modeling and data management thought that an objective of modeling should be the ability to model water quality with the same accuracy as one can measure it. The group thought that this was now possible for quantity models.

The group recommended that existing data should be assembled and made available to researchers for further analysis. There was a perception that much greater understanding can be gained from study of these data. Another recommendation was to develop methods to estimate modeling uncertainty quantitatively and incorporate these methods into stormwater quality models. The ability to determine how good models are is a prerequisite to determining whether we have good models.

There is also a perception that there is still much that we do not understand and that we must assess what we don't know in order to proceed intelligently. A procedure is discussed that would postulate and examine processes affecting urban water quality in detail. A suggested framework in which to implement this methodology is an urban watershed similar to the Hubbard Brook experimental watershed, which examined the impacts of forestry practices.

Development of a chemical processes model of urban runoff that includes chemical speciation, kinetics and transformations, particularly of processes at the sediment-water interface, was recommended. This model must be able to make use of existing data bases and should improve our ability to properly interpret existing data.

Improved modeling procedures also were recommended, especially methods to help proceed intelligently through an analysis, using both simple and complex models in concert with technologies such as expert systems and sensitivity and error analysis. These systems should

include procedures to identify optimum data requirements. It was thought that regression models can be improved by designing models with better functional forms that include more causal parameters as independent variables.

Several activities to promote technology transfer were recommended by this workgroup. Professional societies should promote access to existing data bases. New data collection activities should follow United States Geological Survey (USGS) guidelines for quality control and reporting format and should use USGS standards for archiving. The USGS should be encouraged to add acceptable processed data to their data base. Training should be provided in the use of models and data on microcomputers and simpler, "user-friendly" ways to approach complex models and data bases should be promoted through the development of pre- and post-processors.

Workgroup on Institutional Issues

Discussion centered around recommended research in institutional issues and activities that would promote better understanding of urban stormwater runoff issues, particularly related to local, regional and state governments. The activities recommended by the workgroup focus on integrating activity at local, regional, and state levels and in the private sector.

The workgroup strongly encouraged EPA to seek out local government and professional participation in the regulation development process for NPDES storm sewer permits.

The group sees the need for a single repository of information on various important aspects of urban stormwater runoff. Examples of information categories are listed in the workgroup report.

Workshops to strengthen urban runoff elements of state implementation programs were seen as a valid activity of regional EPA offices, actively supported by professional organizations. In particular, education and certificate training programs related to Best Management Practices (BMPs) for urban stormwater are needed for local government staffs, the engineering community, and the development/construction community. ASCE, APWA and other appropriate organizations should continue sponsoring programs, activities, and conferences on urban stormwater quantity and quality. These professional activities should be concurrent and supportive of official federal or state activities in the urban stormwater area.

Two research needs were identified by the work group. Research is needed into costs for installation and/or construction, maintenance and operation, monitoring and compliance of urban stormwater BMPs. Research is also needed into institutional frameworks in which state responsibility for water quality and local government responsibility for land use decisions can be integrated. For example, Florida's objective is delegating quality and quantity permitting to the local level. Program criteria need to be established to allow this delegation of authority.

Workgroup on NPDES Permits and Data Requirements

The September 26, 1984 Federal Register regulations require all municipalities with a population over 2,500 within the 366 urbanized areas of the United States (US) to obtain National Pollutant Discharge Elimination System (NPDES) stormwater permits. The workgroup discussed issues arising from this regulation.

A significant issue that has yet to be resolved is exactly who is to be the permittee. To ease the regulatory burden, EPA is considering the issuance of general permits that would not require a permit for each discharge point. In this case, the permittee may range from a shopping center to a municipality to a regional government to a state government. Indeed there is the possibility of a general permit for all shopping centers. Many issues arise from this general permit including responsibility for financing, sampling and enforcement. The work group attempted to identify these issues.

The workgroup believed that objectives for the permit process should be established with certain minimally acceptable scientific and engineering underpinnings. For example, the objectives should include protection of beneficial use of the nation's waterways, protection of groundwater users who may be affected by the permitted flow and associated controls, and consideration of variability of weather, geomorphology, land use mixes and positionings, and perceptions of aesthetic values in different communities.

The workgroup discussed several criteria for a permit, including criteria for variability of rainfall, criteria for definition of a storm event, criteria for violation of a permit, and criteria for definition of "natural water quality." Research needs evolving from these criteria include research on the state-of-the-receiving waters and the effects that stormwater may have on them, including establishment of standards by which stormwater quality can be judged.

There is a need for development of criteria for definition of a storm that will violate water quality standards as this will likely be the basis for design of pollution control facilities. There is a need for criteria for what constitutes violation of a permit and for what constitutes adequate and reasonable data collection requirements for a permit. The group speculated that the National Urban Runoff Study (NURP) data will be taken to be representative of "average" stormwater and will be the basis for comparison of monitoring data for permit compliance purposes. Based on this speculation, the group recommended that monitoring data should be collected by some institution and that institution should continually update the "national average."

Workgroup on Control Technology No. 1

The workgroup based its recommendations on the principle that nonpoint pollution will be decreased by practices that increase infiltration rates, absorption, reaction rate and subsequent sediment deposition or biological consumption, or that decrease desorption, erosion or initial concentration of chemicals in rainfall, on sur-

faces, or in the top layer of soil. Several areas were suggested as worthy of further investigation, including source controls, BMP effectiveness, and structural and nonstructural controls.

Research is needed into the potential for source control measures such as modification of automobile and highway materials and practices that reduce undesirable pollutants such as metals and wood perservatives. Additional work is needed to improve infiltration techniques that lose effectiveness because of clogging, such as in porous pavement, and in the chemical treatment of stormwater. Structural controls that need further work include in-line filters, evaluation of outlet control structures, swirl concentrators, plate separators, presettling filtration, and backwash of filters and filter cloth. The effect of depth on wet pond performance bears investigation, as does the use of wetlands and trees for stormwater pollution control.

Several activities were considered worthy of consideration, including "Public Awareness" campaigns to reduce dumping and littering, a clearinghouse for information exchange (perhaps as an EPA function), regional workshops for technology transfer, and development of design manuals for BMPs.

Workgroup on Control Technology No. 2

The second workgroup on control technology restricted its scope to engineered systems for mitigation of nonpoint source pollution. Non-structural measures such as zoning or public education were excluded from consideration. The group believes that the state-of-the-art in control technology is much better than the state-of-the-practice and only a small portion of what is known is being used.

In commenting on the state-of-the-art, pollutants were categorized as solids, nutrients, or toxics. The group believed that solids control was achivable with source controls, retention, and "dry" and "wet" retention; that nutrients can be controlled with detention and that wetlands are a promising technology; and that toxics can be controlled with retention and infiltration/exfiltration. Work needs to be done on controlling nutrients and toxics with other technologies. However, controls can proceed with existing technologies if necessary. It was observed that almost all state-of-the-art control technology requires little or no use of electro-mechanical devices.

Research needs for improving the state-of-the-art were identified in several areas, including field performance of some technologies, development of performance criteria for commonly used material such as filter cloth, documentation of technology failures, life-time costs of control technologies, and the life-time performance and total system impacts of nonpoint source pollution control.

Other recommended activities deal with transferring knowledge about state-of-the-art technologies to practitioners. These recommendations include encouraging engineering colleges to introduce students to urban stormwater management, and encouraging engineers to include other disciplines such as chemistry and biology on design teams.

And the group recommended convening an Engineering Foundation Conference on Design, Construction and Operation Criteria for Urban Stormwater Management Facilities in 2 years. The thrust of this conference should be the presentation of design, construction, and operation criteria based on actual experience.

Conclusions and Recommendations

Several common themes emerged from the workgroup discussions.

There was much discussion about the impacts of pollutants in urban runoff. It was thought that these impacts tend to be subtle and long-term rather than immediate and obvious, and that the general public and environmental managers do not perceive urban runoff as a problem for this reason. The impact of heavy metals seemed to be a particular concern.

There was also a general consensus that the study of urban runoff should not end with the NURP program. Several groups proposed an intensive, long-term study on the order of the Hubbard Brook experimental forested watershed. Such a study should include side-by-side comparisons of disturbed and "natural" drainage basins and focus on fundamental processes in the urban environment including urban pollutant sources, fate and transport, effects, and control technology.

Perhaps the most commonly expressed need was for the transfer of technology from the researcher to the practitioner. Recommendations to help satisfy this need take several forms, including some type of clearinghouse for information and educational programs on urban stormwater quality

Closely related to this need for a clearinghouse was a recommendation to continue conferences such as this to promote professional exchange in the area. Indeed, it was decided at the end of the conference to implement the recommendation of the Workgroup on Control Technology No. 2 and begin planning for an Engineering Foundation Conference on Design, Construction and Operation Criteria for Urban Stormwater Management Facilities in two years.

Disclaimer

This report was prepared by the authors in their capacities as members of the American Society of Civil Engineer's Urban Water Resources Research Council. While both authors are employed by agencies of the United States Government, the opinions and recommendations in this report should in no way be considered to reflect an official position of either the U S Environmental Protection Agency or the U S Department of Housing and Urban Development.

Attachment

Workgroup Reports

Workgroup on Pollution Sources and Receiving Water Impacts

Jonathan Jones, Chairman
Alan Johnson, Reporter
Carla Palmer
Pat Davies
Bill Odum
Nancy Driver
Bill Walker
Tim Miller
Mike Revitt
Bryan Ellis
Bob Pitt
Bob Bastian
Zdnek Novak

Basic Research needs on Evaluating Impacts of Stormwater

A) Development, refinement and standardization of tools and techniques that will assist in:

- Identifying and evaluating impacts of pollutants/physical factors related to stormwater.

- Conveying message to policy makers and public what constitutes a "problem" and, conversely, identify when a "problem" is corrected.

Specifics -

a. Problem Identification - when is a beneficial use impaired or threatened?

b. Data interpretation methods - what does the data mean once we have it (such as organics and metals)

c. Simplified methodology to evaluate assimilative capacities of various receiving waters: what are appropriate discharges to urban receiving waters?

d. Extent of problem on local/regional levels - how do we account for regional differences in hydrology, soils, instream habitat? What are various outlooks on the issue?

e. Fate of pollutants - effects on groundwater; residual management from stormwater control devices.

B) Methods and data that are appropriate for various beneficial uses that will aid in identifying causative bio-geo-chemical agents that are impairing a desired beneficial use.

Specifics -

a. Better understand sediment/water interactions.

b. Development of appropriate analytical methods for problem pollutants - i.e. what form of the pollutant is causing the problem?

c. Techniques for measuring/identifying sublethal stress in biota.

C) Uniform Approaches to detect trends in the quality and quantity of instream habitat. These approaches would be used to :

a. Evaluate present and future impacts.

b. Assist in location of control facilities (i.e. regional type facilities).

D) Need for further advances in basic environmental sciences as related to stormwater, especially the frequent, small storm event.

Specifics -

a. Impacts and fates of pollutants in different receiving waters such as groundwater and coastal waters.

b. Physical processes of sediment transport

c. Pollutant origin and transport through entire watershed system.

d. Data on storm characteristics as influenced by seasonal meteorological events including: 1) warm/cold weather events; and 2) base flows.

e. Contributions and characteristics of pollutant loads for various land uses (e.g. industrial areas).

E) Need for establishment of a national clearing house for collection and distribution of national and international information related to all aspects of stormwater management (in particular quality aspects). This information could include:

- Manuals of practice on stormwater quality, regulatory ordinances and laws.

- Various court decisions and case law related to stormwater

- Educational materials

- Upcoming conferences, short courses and other educational materials.

- Case histories (both successes and failures)

- Rehabilitation and enhancement methods

- Listing of professionals and their area of expertise.

Ed Herricks, who could not attend the work group meeting, submitted a separate report:

I would like to submit a few comments and suggestions for research needs directed to both specific and general issues associated with water quality and urban runoff.

Short Term Effects Testing

There is little doubt in my mind that short term effects testing is necessary to meet the challenge of regulations which are on the horizon. Every effort should be made to avoid the use of existing water quality criteria for the development of permit limitations. Some explanation is necessary!

As you well know, the existing criteria follow a history built on presumptive applicability. Although some efforts have been made toward site specific criteria development, the focus of existing regulations seems to be water quality based toxics control. One of the major issues in the existing criteria/permit arena is selection of appropriate time-concentration relationships (e.g. what is an acceptable 24 hr average or long term average.)

This group should recognize that urban runoff events are episodic - concentration variability is going to be the norm in any runoff monitoring. My reasoning follows that direct application of existing water quality criteria will result in incalculable differences. Limits are likely to be extremely stringent because conservatism and application factors will produce safety factors on the order of 1000 or so. The environment will be protected but the difficulties faced by urban stormwater runoff managers will be monumental.

I would suggest the following:

1) Develop a laboratory research program (short-term toxicity test emphasis) which carefully evaluates episodic exposure of receiving system organisms to contaminants expected in urban runoff. If carefully performed with some tests providing expected ambient exposures it should be possible to adequately address initial concerns for environmental protection from these tests.

2) Encourage the development of "mechanism" analysis (i.e. Jenkins et. al., this conference) as a means of assessing environmental effects. Note that I used the term environmental here! Jenkins' proposed approach is not really a chemical specific analysis procedure (although it could be), it is a promising approach to dealing with true environmental effects starting with the mechanism of effect at the subcellular level and working upward.

3) As the Jenkins' approach tends to work up the biological hierarchy, a corresponding approach should be directed to working down the hierarchy. This approach will not be as clean as the mechanistic approach (you might take note of EPA's efforts to correlate field effects with laboratory testing) but it should be undertaken. My suggestion would be identification of several long term monitoring sites and carefully develop a program of analysis of these sites. The long term monitoring would meet my requirement for a focus on environmental analysis and mitigation planning nationwide.

Long Term Effects Testing

There has been a common concern expressed by participants about environmental effects. That concern is that we know so little about possible effects (even short term) that we are taking real risks with long term exposure, etc.

I feel this needs to be attacked head on. I have forgotten which speaker said what we need is not a $100 million program for 5 years but a $2 million program for 50 years. My response to analysis of NURP analyses is that it provides us the opportunity to ask the right questions now. We should begin the process of answering those questions. Where innovative techniques are being tried, a 5 or 10 year monitoring program should be established to evaluate effectiveness.

Let me digress for a moment. Natural systems are very resilient. Biologists are now developing tools to measure that resiliency, but its importance is not in short term effects analysis, it is the foundation for long term effects analysis. If we don't follow up on the studies we have done, we will still be speculating 10 or 50 years from now about probable long term effects. If we initiate a long term monitoring program for several sites, including a carefully developed sampling program for physical, chemical and biological parameters we will improve both our question answering and question asking capabilities.

Thus as a major recommendation/research need issue I suggest this conference strongly recommend that an effective, long term monitoring program be developed for urban runoff.

First, the implementation of this long term monitoring program should reflect regional differences in climate and receiving system condition and build on strong existing programs of analysis. For example, it has been very clear at this conference that things are different in Florida and Maryland and Wisconsin and Washington. Several regional centers should be established to reflect these differences and the monitoring effort focused on these centers. Second, it is essential that the proper questions be asked in the development of these programs. The proper questions are well defined and lead to data collection which is responsive to the questions while still being cost effective. Lastly, the regional programs should be coordinated and reviewed regularly. (Although not perfect, NSF's LTER program might serve as a model for what might be done.)

Workgroup on Modeling and Data Management

Wayne Huber, Chairman
Mow-soung Cheng
Mike Collins
Mike Terstriep
Jerry Marsalek
Marshall Jennings

The workgroup first listed the objectives of modeling urban runoff water quality: a) Protection of receiving waters; b) Public health; c) Water supply and water reuse; d) Effects on quantity controls, e.g., sedimentation and erosion. The workgroup felt that one should be able to model water quality with the same accuracy as measurements - stating that this was now possible for quantity models.

RESEARCH NEEDS:

A) Analyze existing data!

The existing data needs to be assembled and made available to researchers.

B) Uncertainty Analysis

Develop methods to estimate modeling uncertainty quantitatively, e.g., first-order error analysis, and incorporate these methods into models.

C) What don't we know?

We must assess what we don't know in order to proceed intelligently. A suggested procedure is to:

a) Identify unquantified micro- and macro- scale processes potentially affecting urban stormwater quality, for example:

Dry weather processes

atmospheric deposition
traffic-related
  pavement
  autos
  traffic counts
wind effects
construction
erosion
canopy, vegetation
particle size and composition
absorption
time and spatial scales

Wet weather processes

rainfall quality
washoff
erosion, sedimentation
time and spatial scales

Transport

sediment transport
routing
transformations

b) Postulate mechanisms associated with each process.

c) Collect data to test postulates.

d) Incorporate mechanisms into models.

A suggested framework in which to implement this methodology is to establish an urban experimental watershed similar to Hubbard Brook.

D) Chemical process modeling

Develop a chemical processes model of urban runoff, including chemical speciation, kinetics and transformations, particularly of processes at the sediment-water interface. In developing this model, we must be able to make use of existing data! For example, we should be able to distinguish total vs. dissolved metals.

E) Improve modeling procedures

Develop methods to help an analyst proceed intelligently through an analysis, using both simple and complex models in concert with technologies such as Expert Systems and sensitivity and error analysis in model pre- and post- processors. These systems should also identify data requirements and indicate data to be measured.

F) Regression modeling

Design simpler models with better functional forms, including more causal parameters as independent variables.

ACTIVITIES (Technology Transfer)

A) Existing Urban Runoff Data

Access to existing data bases should be advertised and promoted by professional societies. The USGS-sampled NURP site data is available now and the remaining sites will be available through the Illinois State Water Survey soon. In addition, a report and magnetic tape of other urban runoff data is available from the University of Florida. The group recommended that individual site data be made available on 5-1/4" floppy diskette. Good cooperation from USGS was noted by the group.

B) New Urban Runoff Data

New data collection activities should follow USGS guidelines for quality control and formats and use USGS standards for archiving. USGS should add acceptable and processed data to their data base to the limit of their resources.

C) Training

Training should be provided in the use of models and data on micro-computers.

D) Access to models

Simpler, "user-friendly" ways to approach complex models should be promoted through the development of pre-processors.

Workgroup on Institutional Issues

Scott Tucker, Chairman
Bart Hague, Reporter
Don Van Sickle
Bob Deeds
Pam Bissonnette
Tom Mountz
Steve Kay
Joan Lee
Eric Livingston
David Peterson
David Zeno

Discussion centered around recommended research in the institutional issues area and activities that would promote better understanding of the Urban Stormwater Runoff issues, particularly related to local, regional and state governments. The evenings' discussion can be distilled to five recommendations on activities and two recommendations on research needs.

RECOMMENDED ACTIVITIES

FOCUS: Integrating activity at local, regional, and state levels and private sector.

A) NPDES Permitting of Storm Sewers

In some manner, EPA should encourage and seek out local government and professional participation at the earliest possible time in the rule/ regulation development process.

B) State Non-Point Source Implementation

Workshops for staffs of state and local agencies and affected professionals are needed to strengthen the urban runoff elements of these state implementation programs. We see this as a valid activity of regional EPA offices, actively supported by appropriate professional organizations.

C) Information and Technology Transfer

The group sees the need for a single repository of information on various important aspects of Urban Stormwater Runoff. Examples of information categories include:

a) Local, regional, state criteria and design manuals.
b) Inventory of BMP facilities.
c) Information on BMP facility operation and maintenance.
d) Information on cost and financing for BMP facility.
e) Monitoring program information.
f) Ordinances and enforcement information.
g) Names/addresses/phone numbers of key contacts at various state, regional, local, and federal agencies.

D) Education and Certification

Education and certificate training programs for local government staffs, the engineering community, and the development (construction) community related to BMPs for urban stormwater.

E) Professional Activities

ASCE, APWA and other appropriate organizations should continue sponsoring programs, activities, conferences, on urban stormwater quantity and quality. The group felt that this professional activity should be concurrent and supportive of official federal or state activities in the urban stormwater area.

RESEARCH NEEDS

A) Costs of BMPs

Research is needed into costs for installation and/or constructing, maintenance and operation, monitoring and compliance of urban stormwater BMPs.

B) Integration of Responsibility

Research is needed into institutional frameworks in which state responsibility for water quality and local government responsibility for land use decisions can be integrated. For example, Florida's objective is delegating quality and quantity permitting to the local level. In this type of approach, program criteria need to be established which could allow this delegation of authority.

Workgroup on NPDES Permits and Data Requirements

Michael Sonnen, Chairman
Pam Bissonette
Dennis Athayde
Robbie Comer
Ayoub Talhami
Linda Hinson
Jerry Higgins
Mary Peters
Fay Baird

The Permittee - Who are they?

The September 26, 1984, Federal Register regulations require all 6,000 or so municipalities with a population over 2,500 that are within the 366 urbanized areas of the US to obtain NPDES stormwater permits. Is this feasible? Who, in fact, should be the responsible party? Can municipalities with common receiving waters take common responsibility in a single permit? What legislative mechanisms would be needed to provide these permittees with financing/sampling/decisionmaking/enforcement authority? The 9 states with general permit authority today can currently apply for a general stormwater permit, but is that a beneficial thing to do, given the varying conditions and site specificity within a state?

Objectives of the Permit

The objectives for the entire permit process should be established, and they should be established with certain minimally acceptable scientific and engineering underpinnings -- no matter what the enabling legislation or compelling lawsuits say they are.

For example, the objectives must include these:

1) Protection of beneficial use of the nation's waterways, whether these are precisely and everywhere the exact same ones as in 303e Basin Plans for "normal" flow periods or not.

2) Ground water beneficial users who are or may be impacted by the permitted flow are also to be protected against deleterious impacts therefrom.

3) Variabilities in conditions of weather, geomorphology, land use mixes and positionings, and perceptions of aesthetic values of natural and man-made waterways exist. Given that they exist, one objective of the permitting process and the permits (plural) themselves shall be (should be) to take such variabilities into account.

Criteria for a Permit

Criterion 1 - Variability of rainfall

The stormwater criteria should be able to reflect the variable nature of rainfall and runoff (in duration, frequency, intensity, etc.) at any monitored site. Criteria that work in Bellevue, WA, may not work in Chicago, IL, or Chesapeake, VA. A feasible first step in stormwater permit criteria development should be to prevent degradation of the extant biota in each region. The "extant biota" in every urban area include, among others, homo sapiens. We need research on the state-of-the-receiving waters and the effects which stormwater may or will have on them.

Criterion 2 - Definition of "natural water quality"

In determining just exactly what water quality criteria should be set, it makes sense to determine stormwater runoff's effects on the biota currently residing in each permittee's waterways. But what baseline can be established if we have a "dead-river" situation or for a river that is severely impaired due to activities occurring upstream? What could be used as a surrogate model for the establishment of standards by which a given degraded "natural" water's or an outlier stormwater's quality can be judged? (Some among the general audience later warned that attempts by local permittees to defend themselves as naturally ugly outliers will and should be looked upon with high suspicion.)

Criterion 3 - Storm Definition

Likewise, what is the storm event with which we should be concerned? Bellevue, WA has used the 1-year, 6-hour rainfall volume as the point beyond which the receiving water quality standards cannot be expected to be maintained. Treatment of rainfall volumes up to that level would, according to well-established research, account for 95% of the pollutant loadings. Should similar definitions be adopted by each permittee, or should they be rainfall and runoff and load-accumulation and washoff characteristics of each area? Or would other definitions or limitations be more appropriate?

Criterion 4 - Violation Definition

Once we have the standards established for each permit area, what should be considered to be a violation of those standards? If we exceed the standards we have set, by how much and how often do we have to exceed them to be justifiably, actionably considered to be "in violation of the permit"?

Analyses

Nobody yet understands what to do with the data the permittee will surely be asked to submit. No data-requester/demander should ever request or demand until he tells the demandee what he intends to do with the data. So EPA or whoever should know first what analyses are intended.

One supposes the minimum analyses will be done and those will address the basic point, i.e., is this permittee operating in a "normal" background situation or is he abnormal? How abnormal is he? That can be determined by comparing the permittee's sample data against national averages. (Some among the general audience later thought this was a somewhat gross simplification of what ought to be done. That's true, but comparisons against the historical NURP data are to be anticipated!) One expects the NURP data will represent the national average, but the national average should be an ever-improved set of computations based on data from all local cooperators, NURP, USGS, and all other available sources. Some institution should be commissioned to accept the data and continually update the "average." The "average" should be a combination of statistics on rainfall

amounts, frequencies, storms per year, flashiness of storms, length of dry periods and similar related weather and climatological data.

Next the analyses should include permittee's quality distributions and how they compare with the national averages. Statistics such as exceedance or frequency relationships of concentrations in a number of samples at a point should be computed and arrayed. For example, there should be a plot of concentration of, say, zinc vs. % of time that concentration is exceeded in samples -- of dry weather flow and of storm flow.

Additionally, the permittee's submitted quality records should be analyzed against the submitted records of other applicants in his own region. For example, if city E in the center of a box configuration of cities A, B, C, and D says his background receiving water lead concentration is 12.4 mg/l and the city A-to-D data show 0.02, 0.004, 0.8, and 0.000358 mg/l; then city A's data should be held suspect.

Data

The basic physical, stream or outfall data requirements to support a requested permit will be the menu of properties and constituent concentrations that describe the baseline condition of the permittee's receiving water or waters. That menu is not knowable at this point as a single list of properties applicable to all permit requesters. There is nothing sacred about NURP's sampling scheme that would preclude testing for different, more relevant stormwater constituents.

The second data need will be the minimum acceptable sampling plan for each permittee. At a minimum this should include the number of sites to be sampled, the number of storms to be sampled at each site or at all sites, and the number of samples to be taken at each site or at all sites. (The "ors" should be negotiable.)

There are also important, very basic definitions required, which are basic "data" too. What is the definition to be of:

1) a "receiving water" (and is there only one definition?);

2) a "sampling site" (in a pipe, in a pond, in a stream, at the edge of a parking lot, in a "watershed" someplace?);

3) what is an "outfall" and when or how is an "outfall" not an outfall?

Lastly, a regulator may never require a permittee to submit information on cost effectiveness or cost justification, but most, if not all permittees will want to have the cost justification data to display at the drop of a hat. Useful, information-containing, visually compelling data formats and data entries should be developed (in tables or graphs -- such as: Monitoring Cost in $ per saved human life (say $100,000,000) or BMP cost in $ per unaffected Anabena cell (say $12.50)).

Workgroup on Control Technology No. 1

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The workgroup based its recommendations on the principle that nonpoint pollution will be decreased by practices that increase

a) Infiltration rates
b) absorption, reaction rate and subsequent sediment deposition
c) biological consumption

or that decrease

a) Desorption
b) Erosion
c) Initial concentration of chemicals in rainfall, on surfaces, or in the top layer of soil.

RESEARCH NEEDS:

Several areas were suggested as worthy of further investigation, including:

A) Source Controls

Research is needed into the potential for source control measures such as modification of automobile and highway materials and practices to reduce undesirable pollutants, i.e., Zn, Cd, Cr, and wood treating chemicals such as creosote, etc.

B) Effectiveness of BMP's

a) Infiltration techniques lose effectiveness because of clogging such as in porous pavement.
b) Chemical treatment of stormwater, i.e., alum, activated carbon, reverse osmosis, etc.

C) Structural Control

a) In-line Filters
b) Evaluation of Outlet Control Structures
c) Swirl concentrators
d) Plate separators
e) Pre-settling filtration
g) Backwash of filters and filter cloth

D) Effect of depth on wet pond performance - nutrients, etc.

E) Evaluation of Wetlands

a) Contact times for Removal
b) Yearly mass balances
c) Include shallow marshes

F) Use of trees for pollution reduction

ACTIVITIES:

Several activities were considered worthy of consideration:

A) Public Awareness campaigns to reduce dumping and littering.

B) Clearing House for Information Exchange (Perhaps as an EPA function)

C) Regional Workshops for Technology Transfer.

D) Development of Design Manuals for BMP's

Workgroup on Control Technology

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Introduction

To confine the scope of our workshop, we defined control technology as engineered systems used to mitigate non-point source (NPS) pollution. Control technologies include source control (e.g., mulching, seeding), vegetative buffer strips (e.g., natural vegetation along stream channels), infiltration/exfiltration (e.g., perforated pipes discharging into the ground water system), retention with no discharge to the surface water system (e.g., as applied in Florida), "wet" detention (i.e., permanent pool with discharge to the surface water system), "dry" detention (i.e., discharge to the surface water system), "wet" and "dry" detention with filtration (followed by discharge to the surface water system), wetlands and other vegetative systems, and chemical treatment.

Non-structural measures such as land zoning or down-zoning and public education are excluded from our definition of control technology. However, such measures are an integral part of NPS pollution control systems and, therefore, should be considered in planning and design.

There is a large gap between the state-of-the-art (SOA) and the state-of-the-practice (SOP) in NPS control technology. As a group, water resource engineers seem to be using only a small portion of what is known about NPS control technology. Stated differently, only a very small fraction of practitioners seem to be using SOA technology.

Comments on the State-Of-The-Art

For purposes of discussion, NPS pollutants/contaminants were categorized as being primarily solids, nutrients, or toxics. Given this scheme, we believe that engineers can be confident in controlling solids using source control, retention, and "dry" and "wet" detention. By "confident", we mean that an engineer with sufficient watershed and site data and familiarity with the SOA, could design a solids control facility, "sign off" on a design, and see it go to construction and into operation. With the exception of special situations, we lack adequate information to confidently control solids using detention with filtration and using vegetative buffer strips.

We are confident that nutrients can be controlled with retention. Natural and artificial or restored wetlands appear promising. We need to advance the SOA in controlling nutrients with all other technologies.

Finally, toxics can be confidently controlled with two technologies -- retention and infiltration/exfiltration. We need to advance the SOA in using other technologies to manage toxics in the environment.

In summary, the SOA provides at least one technology to control each of the three pollution categories. Therefore, we can proceed with implementation of NPS controls in at least some parts of the United States as local problems may require. However, cost-effective solutions are much more likely to be achieved if the SOA is advanced with respect to all technologies. That is, availability of a range of technologies will provide the designer with more options and increase the likelihood of a more cost effective solution. Furthermore, advancing the SOA for all technologies will make proven controls

available regardless of climatic, soil, topographic, and other conditions.

We observed that almost all SOA control technologies are "gravity driven". That is, there is little or no use of mechanical devices (i.e., moving parts), automatic controls and pumping. Reliance on gravity systems seems prudent for two reasons. First, the introduction of mechanical and electrical devices will exacerbate the already difficult inspection and maintenance function. Second, mechanical and electrical devices are most likely to fail when they are needed most — during storms.

Research Needs

A) We need to know more about the field performance of some control technologies. Of particular interest, because of their potential application to two or more classes of pollutants or contaminants, are source control, vegetative buffer strips, infiltration/exfiltration, "wet" and "dry" detention with filtration, and wetlands.

B) Performance criteria should be developed for commonly used materials such as filter cloth, particularly when used as a silt fence.

C) To the extent feasible, control technology failures should be documented and shared.

D) Although we have sufficient information to estimate construction costs, we need additional research to define inspection, maintenance, and operation requirements or tasks and associated costs. We also need to know the useful life of system components, that is, the various parts of a given control technology. The over-riding concern is that NPS technologies may be operation and maintenance intensive. Therefore, the present value of inspection, maintenance, operation and replacement costs may be of the same order of magnitude as construction cost.

E) It seems possible, if not probable, that SOA NPS control technologies could be satisfactorily applied to an urbanizing watershed and serious channel erosion and sedimentation still develop over a period of years and decades on the trunk channel system. Such erosion and sedimentation would be caused by the change in the hydrologic regime (e.g., higher discharges and velocities) in the channel system. Concern with long term erosion and sedimentation in the trunk channel system is one reason that stormwater management in urbanizing areas must simultaneously address quantity and quality problems. The early emphasis on quantity at the expense of quality must not be replaced by a new emphasis on quality at the expense of quantity. We need case study data to highlight the importance of simultaneously addressing quantity and quality.

Other Recommended Activities

Research such as recommended in the preceeding section of this report will advance the SOA. However, research will not significantly or rapidly advance the SOP. Accordingly, various vigorous technology transfer efforts must continue or be initiated.

A) We recommend the convening, in two years, of an Engineering Foundation Conference (EFC) on Design, Construction, and Operation Criteria for Urban Stormwater Management Facilities. The thrust of this EFC should be the presentation of design, construction, and operation criteria based on field data and other actual experience.

Between now and the conference, we hope that researchers will examine their data to identify and quantify design perameters. Similarly, design practitioners, contractors, and operating personnel should distill their experience as it relates to design, construction, and operating criteria. Because of the informal, confidential nature of EFC's, the conference could be a forum to share failures as well as successes.

We suggest that co-sponsors or participants in this EFC include, but not necessarily be limited to, our international colleagues and U.S. organizations such as the American Association of State Highway and Transportation Officials, the National Home Builders Association, the American Public Works Association, and selected scientific groups. Conference proceedings should include presented papers plus an annotated bibliography of design, construction, and operation manuals and other documents.

B) We recommend that engineering colleges introduce students to urban stormwater management by using this field as an example of the application of engineering sciences such as hydraulics, hydrology, soil mechanics, sanitary engineering, and structures.

C) We recommend that engineers invite representatives from other disciplines such as chemistry and biology to participate on planning and design teams.